TP 3959

TRAIN DATA RECORDING SYSTEM

MILESTONE REPORT
Prepared for the
TRANSPORTATION DEVELOPMENT CENTRE
October, 1982

MPB

CA1
DTC 801
8
TG
c.

B TECHNOLOGIES INC.
051 North Service Road, Trans Canada Highway
P.O. Box 160
Ste-Anne-de-Bellevue, Québec, Canada H9X 3L5

MPB TECHNOLOGIES INC.
P.O. Box 160
21051 North Service Road | Trans-Canada Highway
Ste-Anne-de-Bellevue, Québec H9X 3L5 | Téléphone (514) 457-2035

Library and Information Centre / Centre de Documentation (GSLA)
RECEIVED - REÇU LE
APR 6 1983
Transport Canada / Transports Canada

MPB

TP 3959

TRAIN DATA RECORDING SYSTEM

MILESTONE REPORT
Prepared for the
TRANSPORTATION DEVELOPMENT CENTRE
October, 1982

by

R.J. Clark
Assistant Vice-President
Digital Products & Technology

MPB Technologies Inc.
21051 North Services Road
Trans Canada Highway
P.O. Box 160
Ste. Anne de Bellevue, Quebec H9X 3L5

TRAIN DATA RECORDING SYSTEM

TDC PROJECT NO.4462

MILESTONE REPORT

PHASE I UP-M-310

PREPARED FOR THE

TRANSPORTATION DEVELOPMENT CENTRE

BY

MPB TECHNOLIGIES INC.

TRAIN DATA RECORDING SYSTEM

BY

R.J. CLARK

ASSISTANT VICE-PRESIDENT

DIGITAL PRODUCTS & TECHNOLOGY

MPB TECHNOLOGIES INC.

OCTOBER, 1982

PROJECT TEAM

The project team for MPB Technologies Inc. was comprised of:

Mr. R.J. Clark

Mr. A.R. Ferguson

Mr. G. Guevara

Mr. A. Evers

and others

REPORT DOCUMENTATION FORM

1. Transport Canada Report No.	2. TDC Project No.	3. Recipient's Catalogue No.
TP 3959	4462	

4. Title and Subtitle	5. Report Date
TRAIN DATA RECORDING SYSTEM Milestone Report	OCTOBER 1982
	6. Performing Organization Report No.
7. Author(s)	8. Transport Canada File No.
R.J. Clark	D1465-357
9. Performing Organization Name and Address MPB Technologies Inc. 21051 North Service Road, Trans Canada Highway P.O. Box 160 Ste-Anne de Bellevue, Quebec H9X 3L5	10. DSS File No. 17ST.T8200-1-1522
	11. DSS or Transport Canada Contract No. 1ST81-00120
12. Sponsoring Agency Name and Address Transportation Development Centre (TDC) 1000 Sherbrooke Street West Suite 2421 Montreal, Quebec H3A 2R3	13. Type of Report and Period Covered Milestone, September 1981- October 1982
	14. Sponsoring Agency Code TDC 4462
15. Supplementary Notes	16. TDC Project Officer W.G. Rowan

17. Abstract

This report presents the results of Phase I of the two-phase research and development program aimed at developing a completely solid state, microprocessor controlled train data recording system (TDRS). The preliminary design and fabrication of a "bread-board" prototype TDRS unit, consisting of a recording unit for installation on a locomotive, a portable memory unit for transferring data from locomotive to site of the playback system which itself consists of a Keyboard, CRT display, control unit and printer, is documented. A preliminary specification with schematic and block diagrams, as well as a description of the recording system equipment,is included.

18. Key Words	19. Distribution Statement
Rail, train, locomotive, data recorder, microprocessor, computer	A limited number of copies are available from the sponsoring agency

20. Security Classification (of this report)	21. Security Classification (of this page)	22. No. of Pages	23. Price
Unclassified	Unclassified	46	No charge

TDC CDT 79-005

FORMULE DE DOCUMENTATION POUR RAPPORT

1. N° du rapport Transports Canada	2. N° de l'étude — CDT	3. N° de catalogue du destinataire
TP 3959	4462	

4. Titre et sous-titre	5. Date du rapport
TRAIN DATA RECORDING SYSTEM Milestone Report	octobre 1982
	6. N° du rapport de l'organisme exécutant
7. Auteur(s)	8. N° de dossier Transports Canada
R.J. Clark	D1465-357
9. Nom et adresse de l'organisme exécutant MPB Technologies Inc. 21051 Voie service nord, la transcanadienne C.P. 160 Ste-Anne de Bellevue, Québec H9X 3L5	10. N° de dossier — ASC 17ST.T8200-1-1522
	11. N° de contrat — ASC ou Transports Canada 1ST81-00120
12. Nom et adresse de l'organisme parrain Centre de développement des transports (CDT) 1000 o., rue Sherbrooke Suite 2421 Montréal, Québec H3A 2R3	13. Genre de rapport et période visée septembre 1981-octobre 1982
	14. Code de l'organisme parrain CDT 4462
15. Remarques additionnelles	16. Agent de projet — CDT W.G. Rowan

17. Résume

Ce rapport rend compte des travaux de la première des deux phases du programme de recherche et de développement visant à mettre au point un système d'enregistrement des paramètres de fonctionnement d'un matériel roulant, système complètement transistorisé et commandé par microprocesseur. Il présente l'étude préliminaire ainsi que le montage sur table d'un prototype comportant un enregistreur embarqué et une mémoire portative pour transférer les données enregistrées à l'unité de lecture, celle-ci étant elle-même formée d'un clavier, d'un écran cathodique, d'un organe de commande et d'une imprimante. Enfin, il propose un avant-projet de devis pour le matériel d'enregistrement envisagé, accompagné des schémas de principe et fonctionnel.

18. Mots-clés	19. Diffusion
Matérial roulant, Locomotive, Enregistreur de données, Microprocesseur, Ordinateur	Le CDT dispose d'un nombre limité d'exemplaires.

20. Classification de sécurité (de ce rapport)	21. Classification de sécurité (de cette page)	22. Nombre de pages	23. Prix
aucune	aucune	46	aucun

CDT/TDC 79.005

ACKNOWLEDGEMENTS

The authors gratefully acknowledge the advice and assistance provided by the personnel of the Canadian Pacific Railways Limited and TDC, in particular Mr. Frank Haney, Mr. R. Reynolds, Mr. W. Mummery and Mr. W.G. Rowan.

TABLE OF CONTENTS

		PAGE NO.
1.0	INTRODUCTION	1
2.0	SYSTEM DESCRIPTION	2
	2.1 General	2
	2.2 Recorder System	2
	2.3 Playback System	2
	2.4 Portable Memory	3
3.0	PHASE I - BREADBOARD UNIT	4
	3.1 Work Statement	4
	3.2 Results	5
	3.3 Recommendations	5
4.0	PHASE II - PROTOTYPE UNITS	6

APPENDIX A - TDRS Specification

LIST OF FIGURES

		PAGE NO.
FIGURE 1 -	TDRS APPLICATION DIAGRAM	6
FIGURE 2 -	LIST OF TRAIN OPERATING PARAMETERS	7
FIGURE 3 -	TDRS RECORDER SCHEMATIC FOR EXTERNAL SIGNAL/SENSORS/CABLES	8
FIGURE 4 -	TDRS RECORDER BLOCK DIAGRAM	9
FIGURE 5 -	TDRS PORTABLE MEMORY BLOCK DIAGRAM	10
FIGURE 6 -	TDRS PLAYBACK UNIT BLOCK DIAGRAM	11
FIGURE 7 -	EQUIPMENT PHOTOGRAPHS	12

1.0 INTRODUCTION

Canadian railway officials have indicated that there is a need for a rugged, reliable economic train data recording system capable of logging some twenty or more parameters over a continuous period of two days or longer. Such a system would employ a recorder mounted in the locomotive, optional CRT display unit for the engineman, playback unit consisting of a keyboard control unit and teletype printer in a fixed location and a portable memory transfer unit. Existing train recording equipment has been based on magnetic tape recorders which have suffered mechanical failures attributable to the harsh locomotive operating environment.

MPB Technologies Inc., with the cooperation and endorsement of CP Rail, responded to the need by proposing to develop an all solid state microprocessor controlled train data recording system under a two-phased program described in its unsolicited proposal submitted to Department of Supply and Services in early April, 1981. The proposal was accepted in principle by the Industry of Trade & Commerce and the Canadian Transport Commission, and directly sponsored by the Department of Supply and Services and Transport Canada Research and Development Center, and is now being implemented.

The project objective is to develop a solid state microprocessor controlled train data recording system (TDRS) in which the recording unit itself is installed in locomotives. The specific objective is to produce a final detailed design package suitable for calling tenders for quality production of all newly developed components of such a TDRS.

In order to achieve the specific objective, a comprehensive two-phase, staged design, prototype fabrication, laboratory and field test evaluation program is being undertaken over a period of approximately two years.

Phase I of the project includes the preliminary design and fabrication of a «breadboard» prototype TDRS unit, elements of which have been functionally tested in both the laboratory and in the field to verify the design. The «breadboard» system consists of a recording unit for installation on a locomotive, a portable memory unit for transferring data from the locomotive site of the playback system, which itself includes a keyboard, control unit and printer. All system components, except the printer, have been designed, fabricated and tested with the recorder unit actually installed on a CP Rail locomotive. System design modifications shall be made in Phase II based on test results to complete the initial phase of the project.

The second phase shall involve the construction of six prototype recording units and two complete playback units. Five recording units and one playback unit shall be made available to CP Rail for field trials while the remaining system shall be maintained in the laboratory for design modifications as required. Environmental and vibration tests shall be independently conducted on the first prototype unit to ensure that the design meets the railway operational requirements. A final design package suitable for calling tenders for quantity production shall be produced.

2.0 SYSTEM DESCRIPTION

2.1 General

Figure 1 is an application diagram illustrating the implementation of the Train Data Recording System.

The recorder system, mounted in the locomotive, records the train operating parameters listed in Figure 2 and stores the recording in a solid state memory for later playback.

The portable memory unit extracts the recording from the recorder and transports it to the playback system.

The playback system stores the recording received from the portable memory on a floppy diskette for playback in a variety of ways on a CRT display and/or printer unit.

The detailed recorder schematic provided in Figure 3 shows the external signals, sensors, and cables.

Figures 4, 5 and 6 are block diagrams of the recorder unit, portable memory unit, and playback system respectively.

Figure 7 consists of photographs of the various system components.

2.2 Recorder System

The recorder system comprises a microprocessor controller and a series of sensors and transducers as shown in Figure 3. The microprocessor controller is shown in detail in the Figure 4 block diagram.

In response to the respective keyboard command the microprocessor controller under software controller reads the various sensor data and stores the readings, as required in the solid state memory.

At the completion of a run (or at any convenient time as determined by the railroad) the recording is extracted by the portable memory, or by some other external system, for replay by the playback system.

Details of the train data recorder system operation and operating characteristics are provided in the TDRS Specification in Appendix A and User's Manual in Appendix B.

2.3 Playback System

The playback system shown in Figures 1 and 6 comprises the following main components:

- microprocessor controller
- keyboard unit
- CRT display unit
- printer unit

In response to the respective keyboard command, the microprocessor controller requests the recording from the portable memory (or recorder directly) and stores it in memory for analysis. The recording can be reviewed on the CRT or printed by the printer in a variety of ways, as determined by instructions by the keyboard operator.

Example 1 - Printout recording from REAL TIME XX XX XX
to REAL TIME YY YY YY

Example 2 - Printout recording from Distance A to Distance B

A permanent copy of the recording can be made on a diskette for future recall and analysis.

2.4 Portable Memory

The portable memory shown in Figure 1 and 5 is merely an extension of the playback system without the keyboard, CRT display and printer units.

It comprises a battery operated microprocessor controller with a large solid state memory.

In response to a push button command the microprocessor controller requests the recording from the recorder unit and stores in in memory for later transfer to the playback system.

3.0 PHASE I - BREADBOARD UNIT

3.1 Work Statement

The following work was completed as Phase I of the project.

3.1.1 Work plan, activity schedule, cash flow projection, project management control and documentation procedures for the first phase of the project.

3.1.2 Final performance specifications in consultation with representatives of TDC and the railways. (See Appendix A).

3.1.3 Design of the breadboard unit components incorporating most features of the performance specifications obtained in previous task and/or provided by TDC. Establish production unit cost targets.

3.1.4 Fabrication of the following system components:

- One recording unit (72 V.D.C., approx. size 16" x 16" x 9", weight 25 lbs.)
- One keyboard and control unit (110 V.A.C. fixed location)
- One portable memory unit (approx. size 10" x 15" x 6", weight 7 lbs.)
- One 9" monitoring system (system testing).

3.1.5 Purchase of the following system components:

- One Printer unit
- Several sensor units not existing in the test locomotive. Made set of sensor units available to CP Rail.

3.1.6 Functional testing in laboratory of TDRS components to verify operation. Dleivery of recording unit to TDC for purposes of preliminary environmental, electrical and vibration tests simulating a locomotive environment.

3.1.7 Installation supervision of system components, including sensors in a locomotive, in cooperation with CP Rail personnel for test demonstration purposes.

3.1.8 Monitor and support preliminary field test demonstration performed by CP staff. Maintain a 35 mm colour slide record of system components during field installation and test trial.

3.1.9 Purchase of ten sets of sensors for Phase II of the project.

3.1.10 Milestone report of Phase I including descriptive narrative, drawings, specifications, photographs of illustrations and supporting material in accordance with the reporting requirements detailed in Section 1.

3.1.11 Monthly progress reports.

3.2 Results

The following features are not included in the Phase I TDRS Breadbaord System:

- Recording memory wrap around
- Extended location entry including Railroad and mileage
- Speed checks in the playback system
- Multiple recording storage in the Portable Memory

Investigations indicated the recorder could be built in a smaller assembly, similar to the portable memory unit.

3.3 Recommendations

In an effort to save space the recorder unit should be mounted in a much smaller assembly, similar to the portable memory unit.

4.0 PHASE II - PROTOTYPE UNITS

Phase II of the TDRS project shall comprise building six prototype recorders, two keyboard and control units and two portable memory units for extensive field and environmental testing. The recorders shall be designed into a more compact assembly and all units shall have the completed software operating system.

At the completion of the field trials a final report shall be prepared including recommendations, a detailed specification and drawings suitable for manufacturing purposes.

MPB TECHNOLOGIES INC.
P.O. BOX
STE. ANNE DE BELLEVUE
P.Q. H9X 3L5

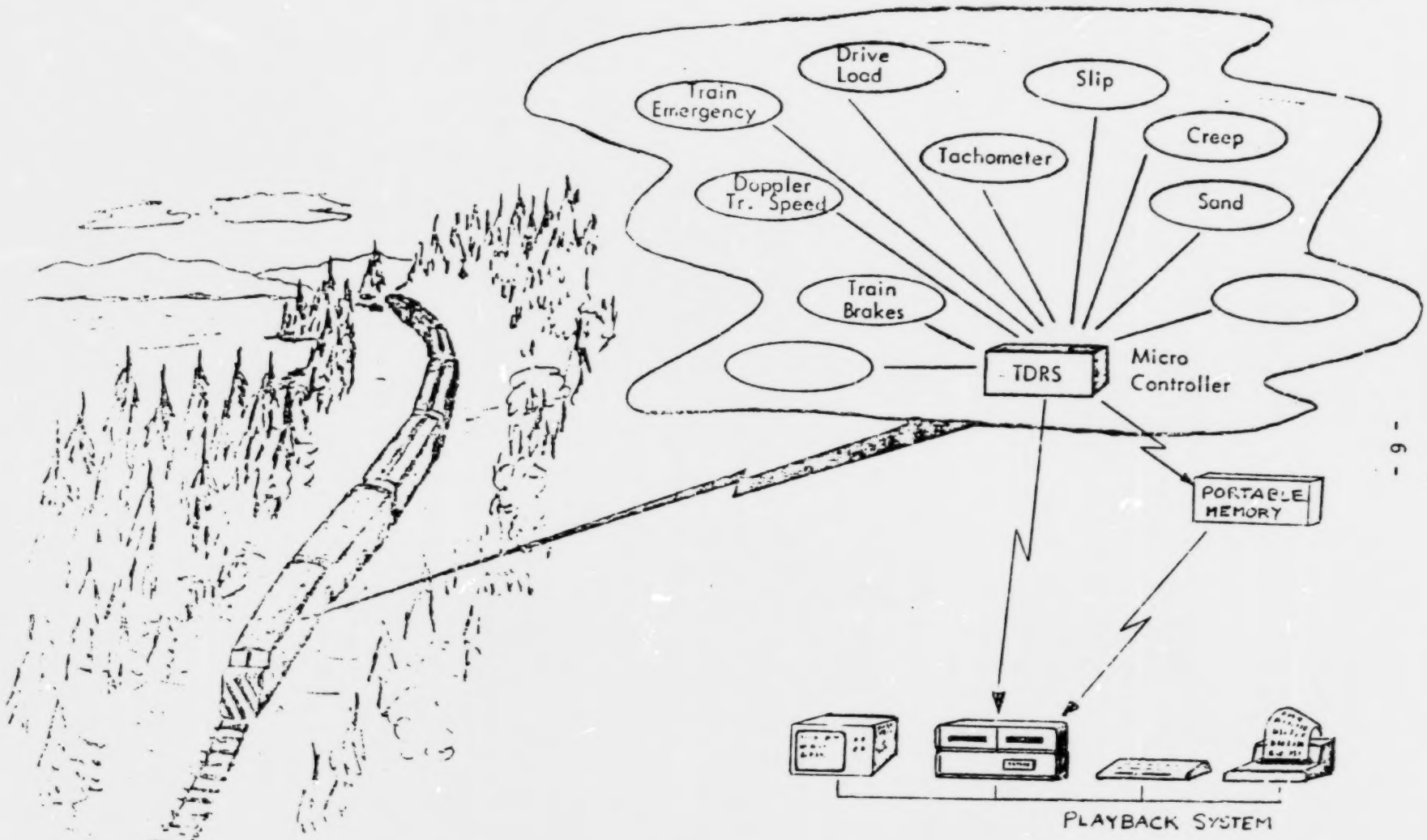
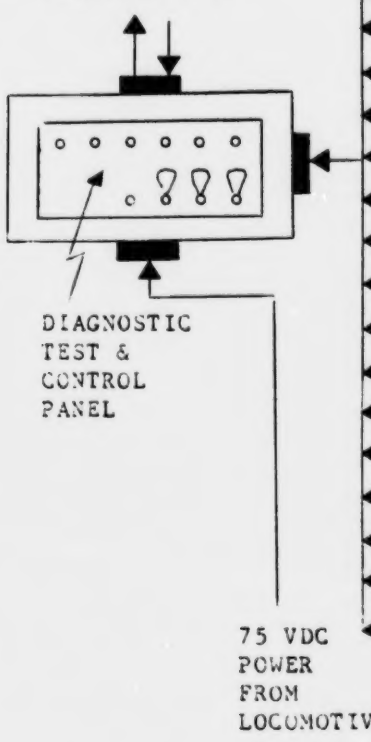


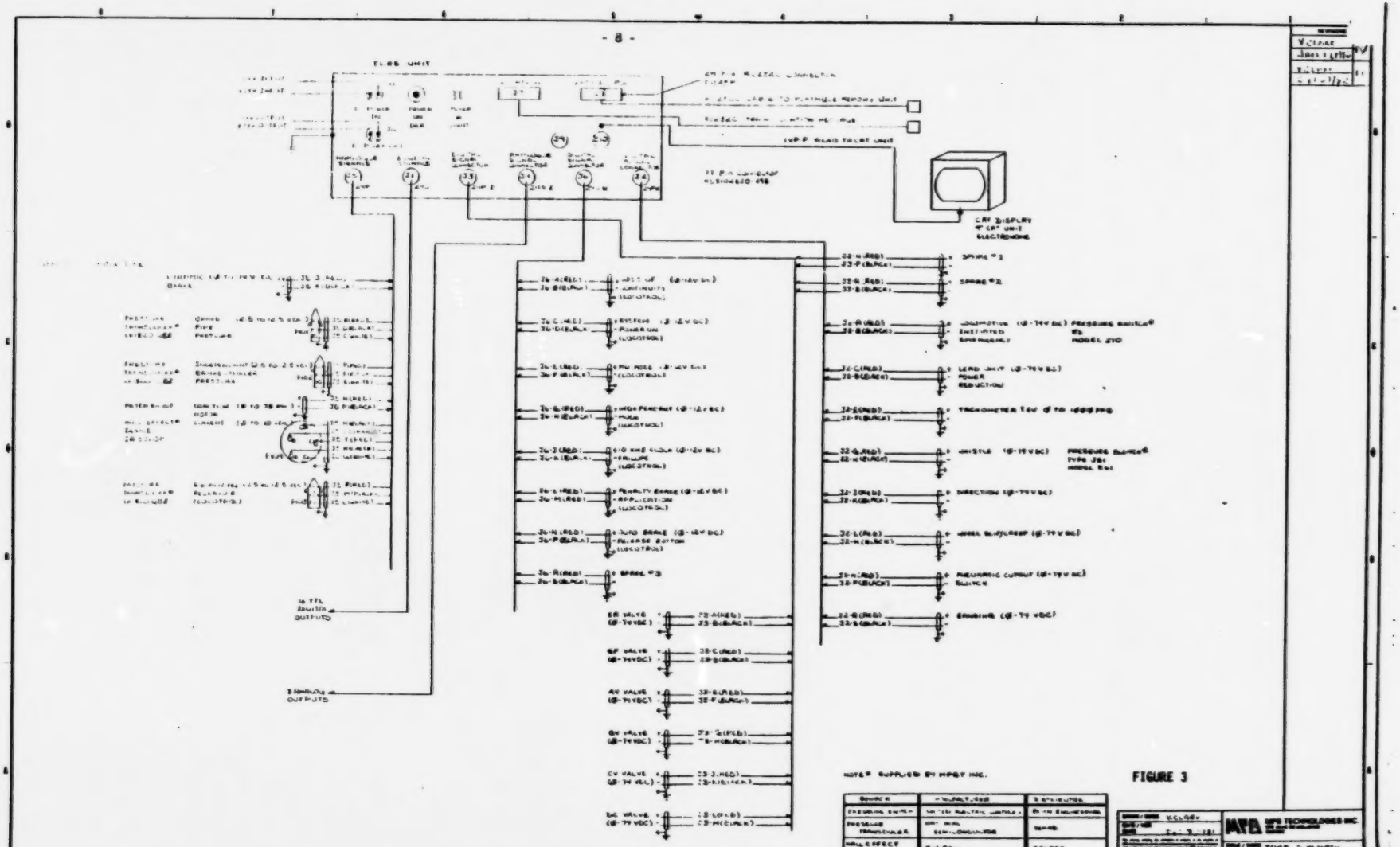
FIG. 1: APPLICATION DIAGRAM - TRAIN DATA RECORDING SYSTEM - (TDRS)



	EVENT	TYPE	RECORDER TYPE BASIC	OPTION 1	OPTION 2
1.	TIME	A	ELAPSED	REAL	ELAPSED
2.	SPEED	A	X	X	X
3.	THROTTLE LEVEL	C	X	X	X
4.	DYNAMIC BRAKE	D	X	X	X
5.	BRAKE PIPE	A	X	X	X
6.	INDEP. BRAKE	A	X	X	X
7.	LOC. INIT. EMERG.	D	X	X	X
8.	LD. UNIT PWR RED	D	X	X	X
9.	SANDING	D	X	X	
10.	WHISTLE	D	X	X	X
11.	DIRECTION	D	X	X	
12.	TRAIN LOCATION	CM	X	X	
13.	DISTANCE	PT	X	X	
14.	TRACTION CURRENT	A	X	X	
15.	WHEEL SLIP/CREEP	D	X	X	
16.	PNEUM. CUTOUT	D	X	X	
17.	LOSS OF CONTIN. (LOCO)	D	X		X
18.	SYSTEM POWER (LOCO)	D	X		X
19.	MU MODE (LOCO)	D	X		X
20.	INDEP. BRAKE (LOCO)	D	X		X
21.	10 KHZ CLOCK (LOCO)	D	X		X
22.	PENALTY BRK (LOCO)	D	X		X
23.	AUTO BRK (LOCO)	D	X		X
24.	EQUAL. RESERV. (LOCO)	A	X		X

TYPE A EVENT = ANALOGUE MEASUREMENT
TYPE D EVENT = DIGITAL (ON/OFF) MEASUREMENT
TYPE C EVENT = CODED DATA
TYPE CM EVENT = CODED DIGITAL
TYPE PT EVENT = PULSE TRAIN

FIGURE 2 - LIST OF TRAIN OPERATING PARAMETERS


ELMS UNIT
CRT DISPLAY W/ CRT UNIT ELECTRONICS
SPARE #1
SPARE #2
LOCOMOTIVE (@ -74V DC) PRESSURE SWITCH
LEAD UNIT (@ -74V DC) POWER REDUCTION
TACHOMETER 16V @ 10 1000 PPR
WHISTLE (@ -74 V DC)
DIRECTION (@ -74 V DC)
WHEEL SLIP/SLIDE (@ -74 V DC)
PRESSURE CUTOUT (@ -74 V DC)
ENGINE (@ -74 VDC)
SPARE #3
AUTO BRAKE (@ -48 V DC)
RELEASE BUTTON (LOCOTROL)
EMERGENCY (LOCOTROL)
THROTTLE (@ -48 V DC)
POWER (LOCOTROL)
DYNAMIC (@ -48 V DC)
CONTINUITY (LOCOTROL)
16 TTL Switch OUTPUTS
8 ANALOG OUTPUTS
DB VALVE (@ -74 VDC)
BP VALVE (@ -74 VDC)
AV VALVE (@ -74 VDC)
BV VALVE (@ -74 VDC)
CV VALVE (@ -74 VDC)
DC VALVE (@ -74 VDC)

NOTE* SUPPLIED BY MPBT INC.

FIGURE 3

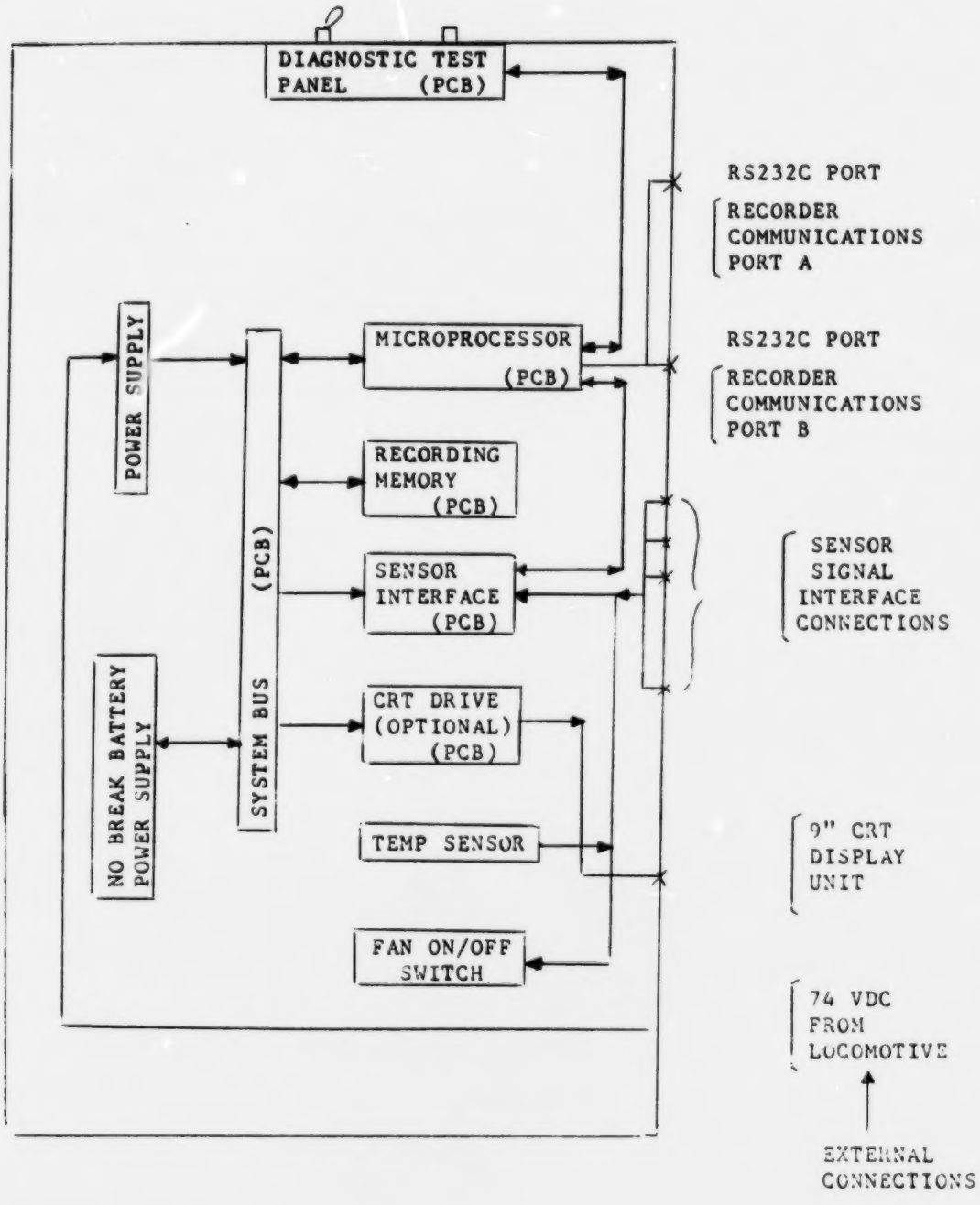


FIGURE 4 - TDRS RECORDER BLOCK DI GRAM

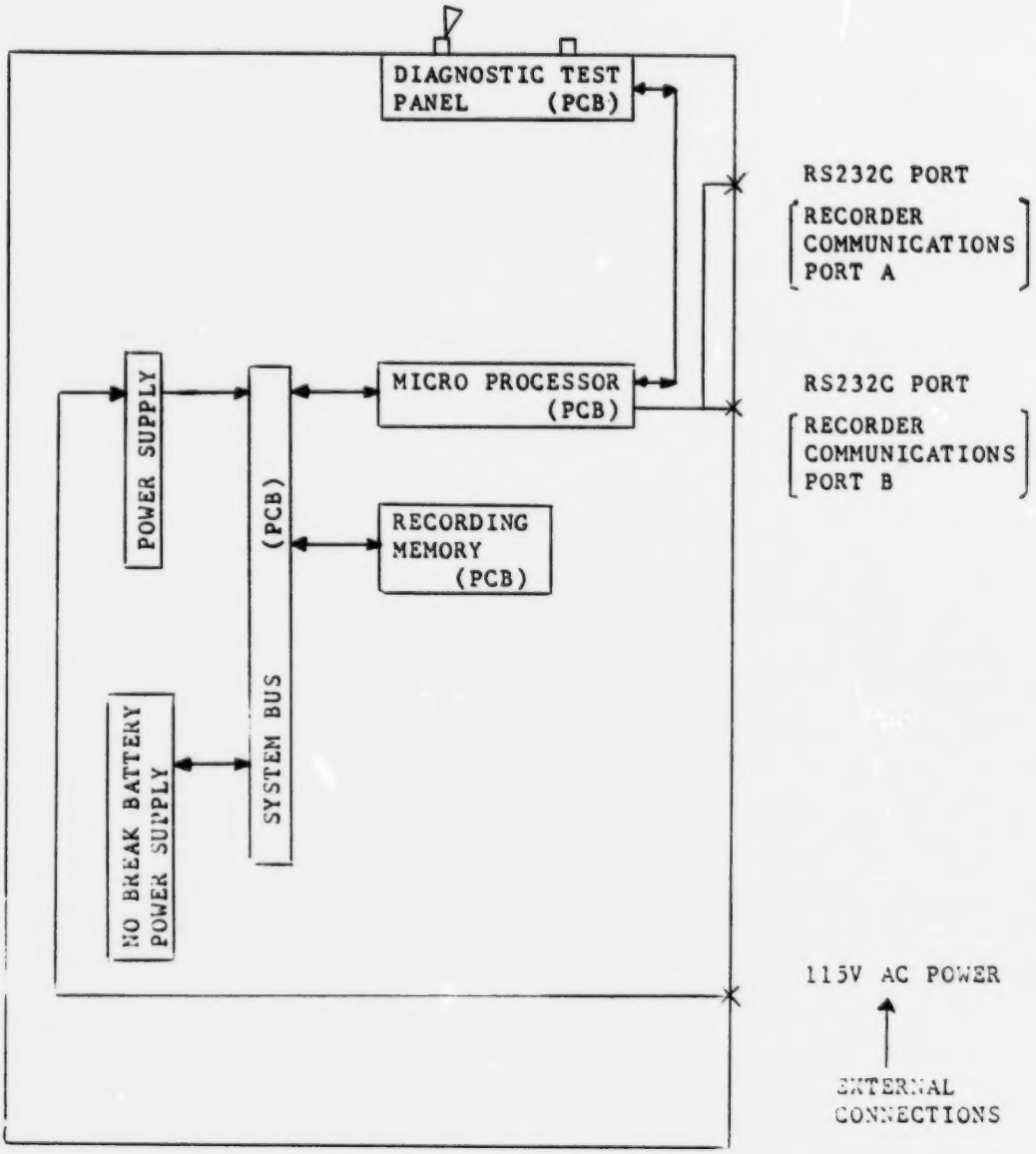


FIGURE 3 - TDAS PORTABLE MEMORY BLOCK DIAGRAM

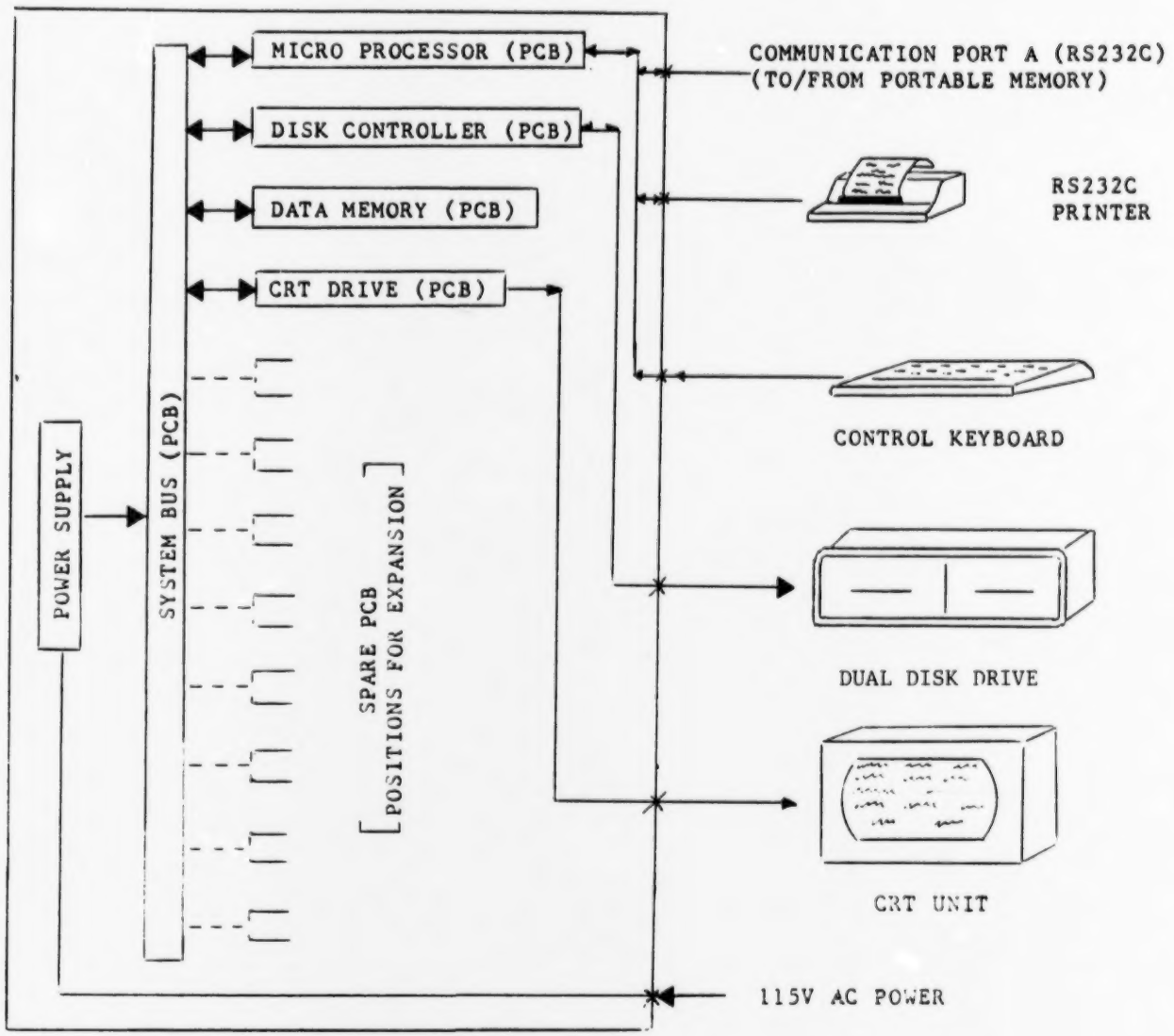
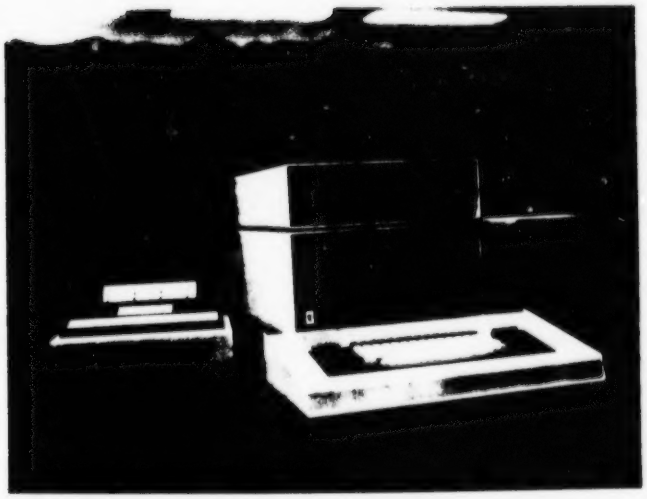
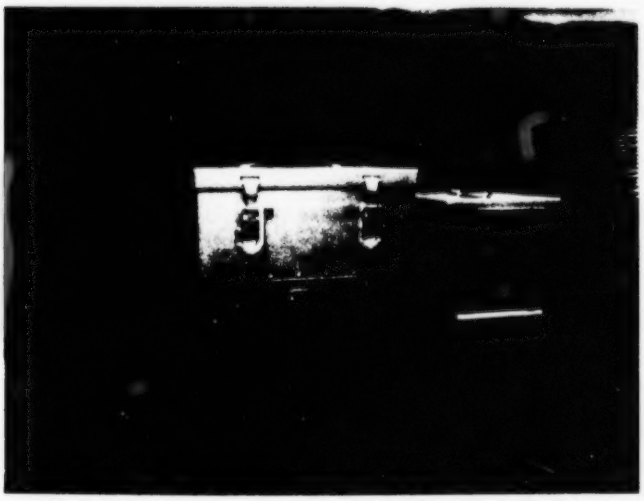


FIGURE 6 - TDRS PLAYBACK UNIT BLOCK DIAGRAM



PLAYBACK
SYSTEM



PORTABLE
MEMORY

PORTABLE
CRT UNIT

RECORDER
UNIT

FIGURE 7 - EQUIPMENT PHOTOGRAPHS

APPENDIX A

TDRS SPECIFICATION

PRELIMINARY

SPECIFICATION FOR A

LOCOMOTIVE EVENT RECORDING SYSTEM

SPECIFICATION FOR A LOCOMOTIVE EVENT RECORDING SYSTEM

TABLE OF CONTENTS

1. INTRODUCTION

2. GENERAL CONDITIONS

3. DESCRIPTION OF EQUIPMENT

4. RECORDING REQUIREMENTS

5. OUTPUT EQUIPMENT AND FORMAT

6. INTERCONNECTION WITH OTHER SYSTEMS

7. HARDWARE REQUIREMENTS

1.0 SCOPE

1.1

This specification covers the supply of equipment and supervision of installation for a locomotive event recorder and playback system for diesel-electric locomotives to be furnished by the vendor.

The purpose of the equipment is to:

a) record basic locomotive operating parameters as a «crash recorder»

b) record, in addition to (a), certain operating parameters useful for crew education, discipline and investigations

c) record, in addition to (a), certain operating parameters required to monitor operation of «Locotrol». «Locotrol» is a system for controlling, by radio, unmanned mid-train locomotives.

2.0 GENERAL CONDITIONS

2.1

Design, equipment, material and workmanship shall be of consistent high quality. All electrical equipment shall conform to CSA standards where applicable.

2.2

The Vendor shall ensure that any radar speedometer units provided are type approved by the Canadian Department of Communications.

2.3

The Vendor shall purchase all material and supplies required for this system from Canadian manufacturers if such materials and supplies of suitable quality are procurable in Canada upon terms as favourable as elsewhere.

2.4

The Railway or locomotive manufacturer shall perform the installation of all equipment according to the Vendor's detailed instructions. The Vendor shall inspect and approve all work performed by the Railway as it is completed.

2.5

The Vendor shall provide the services of an engineer or technical personnel, as required, for testing each complete system installation. Installation testing of each system shall be carried out in Montreal.

2.6

Nominal supply voltage shall be 74 volts DC ungrounded. Estimated regulation is plus 10 percent and minus 15 percent. Vendor is to state the load requirement for all equipment after Phase I.

2.7

All locomotive mounted equipment shall be suitable for use, either operating or stored in unheated areas on locomotives over any ambient temperature range of minus 40 to plus 70 degrees celsius and over any humidity range of 0 to 100 percent, non-condensing without requiring any adjustment. If auxiliary heating is required in order to meet this specification, the power requirement shall be stated at the end of Phase I. Playback equipment normally located

in an office environment shall be suitable for use over any ambient temperature range of 0 to plus 40 degrees celsius and any humidity range of 0 to 100 percent non-condensing without requiring any adjustment.

2.8

Locomotive speed shall be obtained from a railway supplied axle generator with an output frequency of 60 pulses for each wheel revolution for a standard 39 inch diameter wheel. Wheel diameter is subject to change due to wheel wear.

Locomotive speed as provided by a RADAR Speedometer shall also be monitored if a Radar Speedometer is tested.

2.9

System control shall be performed by microprocessor technology and be designed to be easily added to or altered without undue disruption.

2.10

The system shall be designed to be immune to electromagnetic interference from external sources which may be encountered in the railway environment.

2.11 Maintenance

The system shall use high reliability components to keep maintenance to a minimum and be designed to facilitate ease of maintenance and service. The replacement of any component shall be performed in a straightforward manner and with a minimum of disruption of adjacent components.

3.0 DESCRIPTION OF EQUIPMENT

3.1 Recorder Unit

3.1.1 Recorder Hardware

The Recorder Unit shall be comprised of a microprocessor based controller connected to a series of analogue and digital signal sensors as shown in Figure 1. The controller shall be housed in a unit assembly designed to protect the electronics from a harsh mechanical, electrical and thermal environment.

Salient features of the Recording System Controller are as follows:

- Intel Microprocessor Based System
- Program Memory Capacity - 64 K Bytes
- Data Memory - 4 K byte to 1 Megabyte
- Priority Interrupts - 8
- RS232C Interface Ports - 1 or 2
- Analogue Interface Ports - 1 to 8 Inputs (Expandible)
  - 1 to 8 Outputs (Expandible)
- Digital Interface Ports - 1 to 24 Inputs or Outputs (Expandible)
- Internal Bus Structure - IEEE 796.
- Diagnostic Test Panel - 8 LEDS and 3 Toggle Switches provides for complete hardware self testing diagnostics.

3.1.2 Recorder Software

The recorder unit shall be programmed to scan and monitor all the sensor signals listed in Figure 1. A recording shall be made whenever a digital type of even changes status, or when one of the analogue event changes by a specified amount.

The recording shall provide for a printout of real time and/or elapsed time together with speed and distance.

A simple flow chart of the monitoring and recording software system is shown in Figure 5.

The recorder unit shall perform an automatic self check test to verify that the system is capable of writing and reading data, all external connectors are properly inserted, and all sensors are connected and behaving normally. This test shall be performed each time power is applied to the system and periodically to ensure system integrity. The indicator lamp, in green color, shall be located in the equipment and shall continuously indicate the result of this test. A solid state buzzer with an operating frequency of 1900 Hz shall be located on the equipment and switched at a 2 second rate to audibly alert service personnel of a self check test failure.

3.1.3 Recorder Diagnostics

The recorder unit program shall include a complete set of hardware self test diagnostics which can be run by a service technician to isolate a fault. Typical tests are as follows:

1) Program Memory Test - provides a check sun test on the (ROM) program memory;

2) Data Memory Test - provides a series of RAM memory tests for diagnosing data memory faults to the chip level;

3) CPU Test - Exercises the microprocessing logic;

4) RS232 Interface Test - provides a test for the RS232C Ports using a test connector;

5) Sensor Interface Test - provides a test of the sensor interface circuitry using a test connector or the actual sensors.

3.2 Playback Unit

3.2.1 Playback Unit Hardware

The Playback System shown in Figure 3 shall be comprised of the following equipment:

a) Playback Controller Unit

b) Control Key Set

c) Hardcopy Printer

d) Optional CRT Readout

The Controller Unit shall be housed in a portable unit assembly containing one or two floppy disk drives. A block diagram of the Controller Unit interfaced with the peripheral equipment is shown in Figure 4.

Fixed location and portable playback systems shall be available. The fixed location system shall comprise a Playback Controller Unit connected to a standard model 33 or 35 keyboard/printer unit. The portable system shall comprise a portable Playback Controller connected to a small portable printer unit.

The optional CRT readout can be provided for rapid data scanning and analysis before printout.

3.2.2 Playback Software

The Playback System shall be programmed to provide the following:

a) Receive the data recording from the Recorder Unit via the RS232C interface port and store it on diskette;

b) Printout the status of all recorded functions or calculated functions on each line of output. Digital events shall be shown as "0" if the function is OFF and as a "1" if the function is ON. Analogue events shall be shown as a direct analog reading of the function;

c) The beginning of each page of the printout shall contain the column headings. The format of the columns, from left to right shall be time, distance, speed, speed in excess of a zone speed limit, analogue functions and digital functions;

d) Perform calculations to obtain distance;

e) Check for train speeds that exceed zone speed limits, and by how much;

f) Zone speed limits for each subdivision shall be kept in permanent computer storage (on diskette) for access by the system. Excess speed shall be a speed of 10 percent or greater than the applicable zone speed;

g) Provide a means for entering the subdivision zone speeds on diskette for use by the playback computer;

h) Selectively output sections of the recorded information by distance.

3.2.3 Playback System Test Diagnostics

The playback unit program shall include a complete set of hardware self test diagnostics which can be run by a service technician to isolate a fault.

Typical tests are as follows:

1) CPU Test - Exercises the microprocessor logic a control/display panel;

2) Key Set Test - provides a display of the Keyset codes;

3) ROM Memory Test - provides a check sum test and display;

4) RAM Memory Test - provides a series of memory fault diagnostic tests which pinpoint a fault to the chip level;

5) RS232C Interface Test - provides a test of the RS232 interface ports using a test connector;

6) Printer Unit Test - provides a test pattern printout;

7) Disk Drive Test - provides a series of disk drive tests with resultant LED display of fault status.

3.3 Train Location

Two methods to determine train location are considered in this proposal as follows:

3.3.1 Train Location Transponder

CP Rail can provide the train location signal by installing transponders in the track bed and transceivers in the locomotive. When the locomotive passes over the transponder, the transceiver shall send a message to the recorder via a RS232C interface circuit. Placing the transponders a specified distance apart shall enable the recorder to use the location signals to calibrate the speed/distance signal from the locomotive tachometer (60 cycles per wheel revolution).

3.3.2 Train Location Transmitter

As an alternate or enhancement to the above transponder method of determining location, MPB Technologies Inc. proposes a location identification (STATION NUMBER) transmission system.

A miniature Transmitter (battery powered) having a relatively short range shall continuously transmit its location ID message (STATION NUMBER and Mileage). A Receiver located in the Recorder of a passing locomotive shall read the station number message. If the message is free from errors, the Recorder shall record the station number (together with time) on the data recording. Given a data recording containing station numbers, the playback unit will provide a printout which gives positive train location with respect to station numbers such as:

Smiths Falls	P2666 XXXXX
Prescott	P273Ø XXXXX
Red Deer	P8285 XXXXX

where P = Railroad ID Code (P = CP RAIL, N = CN)

2666 = Smiths Falls STATION NUMBER

XXXXX = Mileage to 1/100 of a mile

Recordings having positive location identification, have the added advantage that they can be stored in computer data banks for future use in analysing train load performance for a particular division. Without positive train location it will be more difficult to correlate recordings for a particular division.

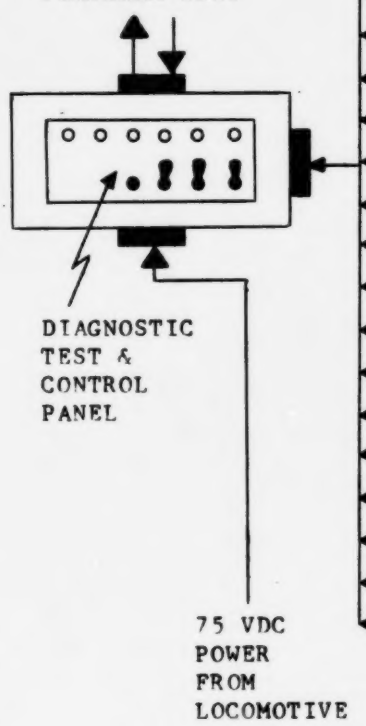
3.3.3 Mean Time Between Failure (MTBF)

The Recorder System shall use high reliability components to keep maintenance to a minimum. An MTBF of 15,000 hours shall be the design target. To minimize the effects of shock and vibration metal castings shall be incorporated wherever possible and signal connections shall be made using qualified components.

3.3.4 Mean Time to Repair (MTTR)

The self testing diagnostics shall enable the service technician to isolate a faulty module or component in minimum time. An MTTR of 10 minutes shall be the design target and replacement of any printed circuit board or other device (power supply, etc.) shall be performed in a straight forward manner and with a minimum of disruption of adjacent components.

To prevent printed circuit damage it is recommended that faulty modules be returned to MPB Technologies Inc. for repair.



EVENT	TYPE	RECORDER TYPE BASIC	OPTION 1	OPTION
1. TIME	A	ELAPSED	REAL	ELAPSED
2. SPEED	A	X	X	X
3. THROTTLE LEVEL	C	X	X	X
4. DYNAMIC BRAKE	D	X	X	X
5. BRAKE PIPE	A	X	X	X
6. INDEP. BRAKE	A	X	X	X
7. LOC. INIT. EMERG.	D	X	X	X
8. LD. UNIT PWR RED	D	X	X	X
9. SANDING	D	X	X	
10. WHISTLE	D	X	X	X
11. DIRECTION	D	X	X	
12. TRAIN LOCATION	CM	X	X	
13. DISTANCE	PT	X	X	
14. TRACTION CURRENT	A	X	X	
15. WHEEL SLIP/CREEP	D	X	X	
16. PNEUM. CUTOUT	D	X	X	
17. LOSS OF CONTIN. (LOCO)	D	X		X
18. SYSTEM POWER (LOCO)	D	X		X
19. MU MODE (LOCO)	D	X		X
20. INDEP. BRAKE (LOCO)	D	X		X
21. 10 KHZ CLOCK (LOCO)	D	X		X
22. PENALTY BRK (LOCO)	D	X		X
23. AUTO BRK (LOCO)	D	X		X
24. EQUAL. RESERV. (LOCO)	A	X		X

TYPE A EVENT = ANALOGUE MEASUREMENT
TYPE D EVENT = DIGITAL (ON/OFF) MEASUREMENT
TYPE C EVENT = CODED DATA
TYPE CM EVENT = CODED MESSAGE
TYPE PT EVENT = PULSE TRAIN

FIGURE 1 - RECORDER SYSTEM APPLICATION DIAGRAM

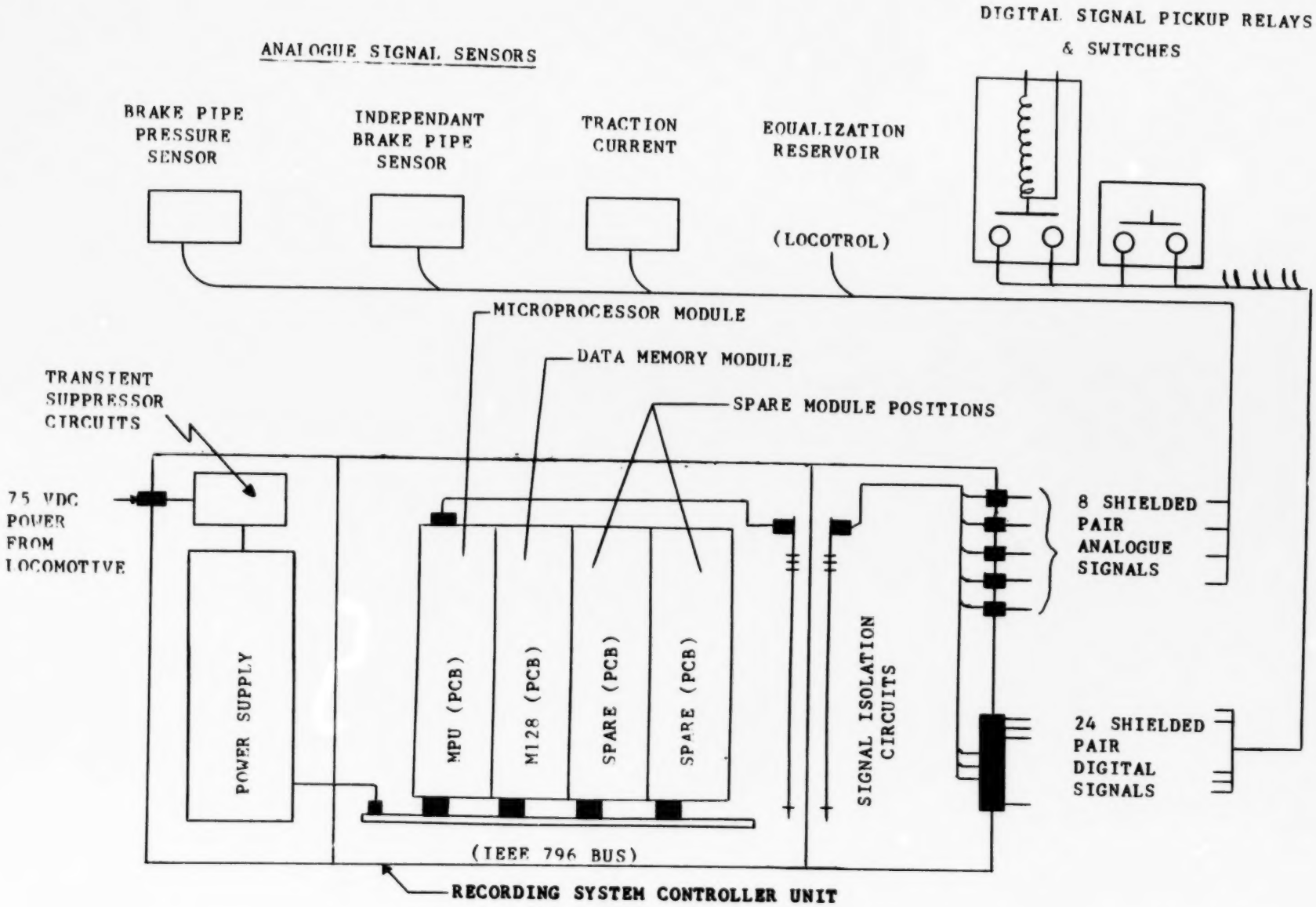


FIGURE 2 - RECORDER SYSTEM BLOCK DIAGRAM

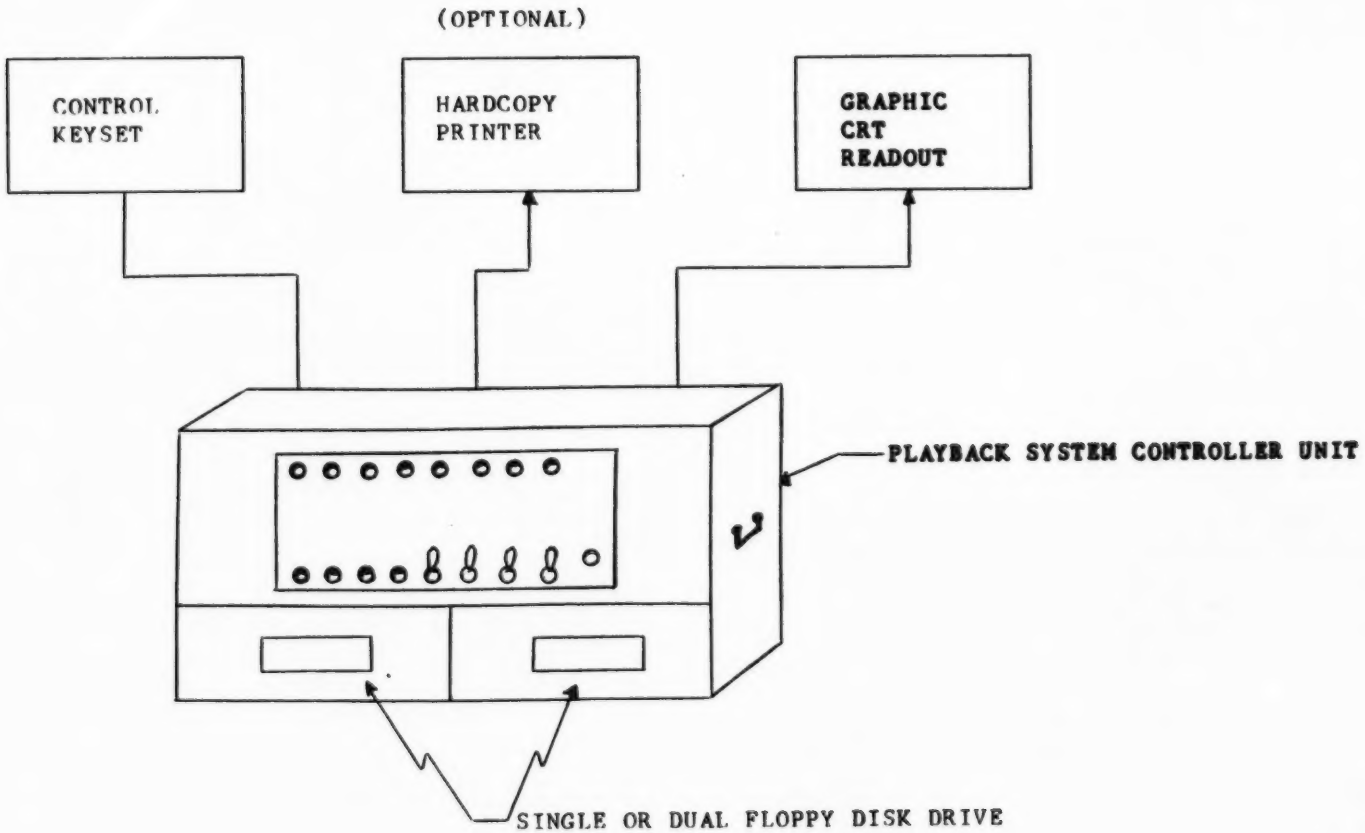


FIGURE 3 - PLAYBACK SYSTEM APPLICATION DIAGRAM

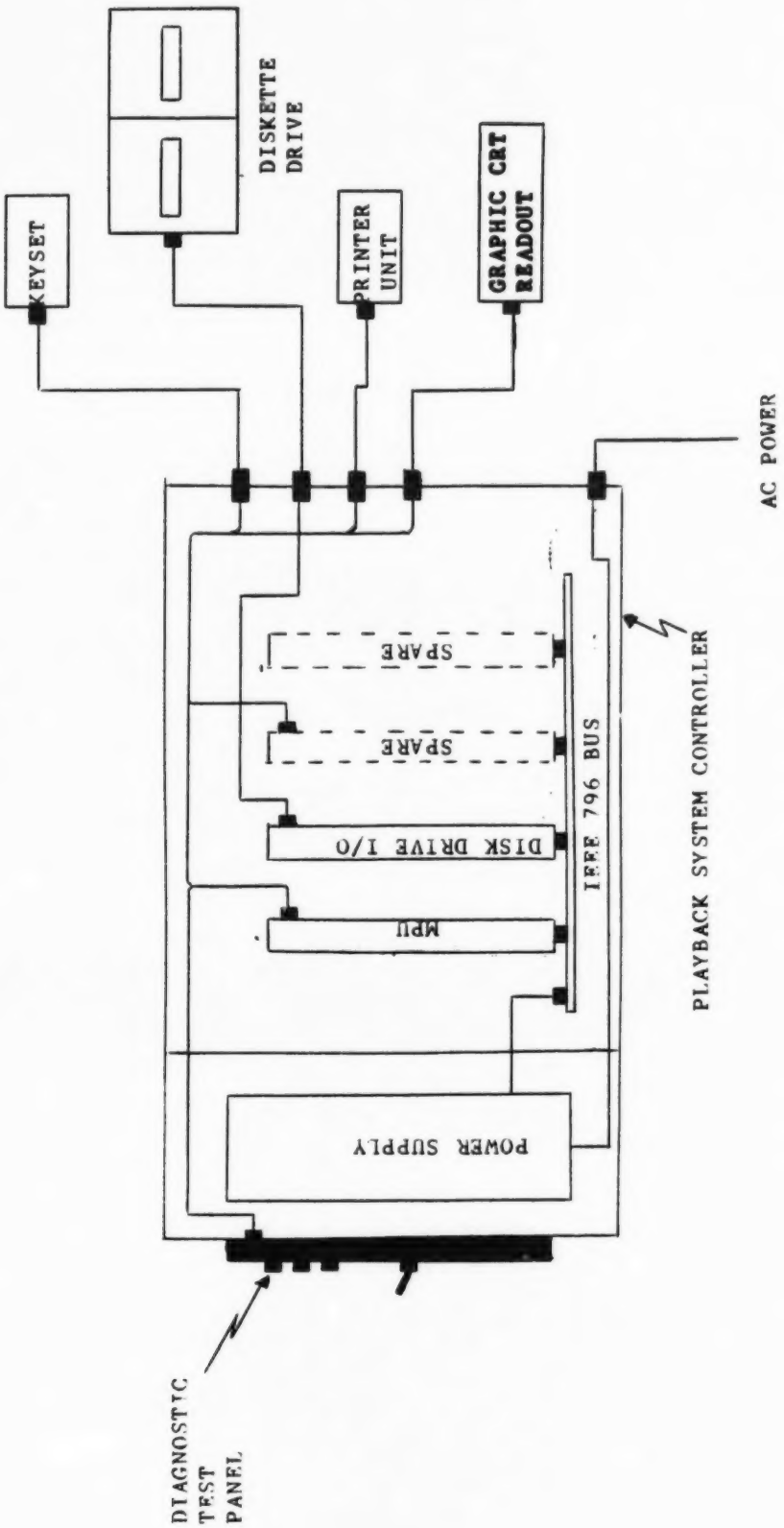


FIGURE 4 - PLAYBACK SYSTEM BLOCK DIAGRAM

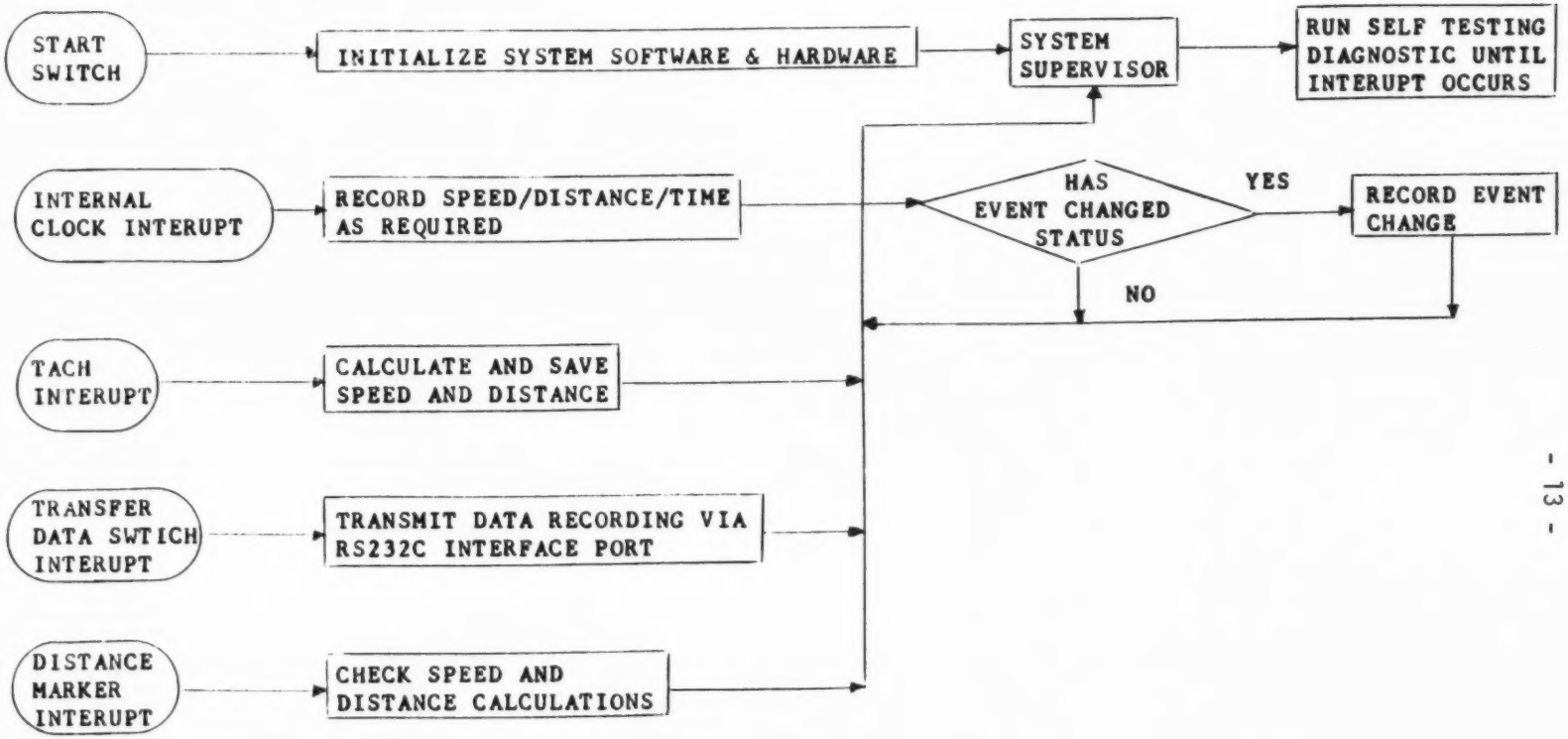


FIGURE 5. FLOW DIAGRAM - RECORDER PROGRAM

4.0 RECORDING REQUIREMENTS

4.1 The following events listed by option shall be sensed and recorded by the system:

EVENTS TO BE RECORDED	TYPE	RECORDER TYPE BASIC	OPTION I	OPTION 2
1. TIME	A	Elapsed	Real	Elapsed
2. SPEED	A	X	X	X
3. THROTTLE LEVEL	C	X	X	X
4. DYNAMIC BRAKE	D	X	X	X
5. BRAKE PIPE PRESSURE	A	X	X	X
6. INDEPENDENT BRAKE CYLINDER PRESSURE	A	X	X	X
7. LOCOMOTIVE INITIATED EMERGENCY	D	X	X	X
8. LEAD UNIT POWER REDUCTION	D	X	X	X
9. SANDING	D	X	X	X
10. WHISTLE	D	X	X	X
11. DIRECTION	D	X	X	
12. TRAIN LOCATION	CM	X	X	
13. DISTANCE	PT	X	X	
14. TRACTION MOTOR CURRENT	A	X	X	
15. WHEEL SLIP, CREEP	D	X	X	
16. PNEUMATIC CUTOUT SWITCH	D	X	X	
17. LOSS OF CONTINUITY (LOCOTROL)	D	X		X
18. SYSTEM POWER ON (LOCOTROL)	D	X		X
19. MU MODE (LOCOTROL)	D	X		X
20. INDEPENDENT MODE (LOCOTROL)	D	X		X
21. 10 KHz CLOCK FAILURE (LOCOTROL)	D	X		X

EVENTS TO BE RECORDED	TYPE	RECORDER TYPE BASIC	OPTION 1	OPTION 2
22. PENALTY BRAKE APPLICATION (LOCOTROL)	D	X		X
23. AUTO BRAKE RELEASE BUTTON (LOCOTROL	D	X		X
24. EQUALIZING RESERVOIR (LOCOTROL)	A	X		X

A - Analog Measurement Required

D - Digital (ON/OFF) Measurement Required

C - Coded Data

CM - Coded Message

PT - Pulse Train

4.2

The system shall sample all items in paragraph 4.1 at a high rate for the basic and Option 2 recorders and at a medium rate for the Option 1 recorder and shall make a recording whenever a digital type of event changes status or when one of the following analog events changes:

4.2.1

Brake pipe pressure by plus or minus 2 psi. max.

4.2.2

Independent brake cylinder pressure by plus or minus 2 psi. max.

4.2.3

Traction motor current by plus or minus 32 amps.

4.3

The system shall record time, speed and distance, whenever a recording is made.

4.4

The system memory shall be capable of recording for one hour for the basic and Option 2 recorders, and for 100 hours and 3000 miles for the Option 1 recorder.

4.5

The basic recorder shall be designed to be easily expanded to accept future additions of Option 1 or Option 2 features.

4.6

At the start of a TRAIN recording run the following data shall be entered by Keyset:

A) TRAIN NUMBER

B) LOCOMOTIVE NUMBER

C) REAL TIME

D) ZONE

E) DATE

F) DIRECTION

G) STATION NUMBER

4.7

Locomotive wheel diameter calibration shall be provided using mile post entries from the KEYSET.

5.0 OUTPUT FORMAT AND EQUIPMENT

5.1

A portable version of the playback system shall be investigated. The system output equipment shall consist of portable equipment for outputting data from the basic and Option 2 recorders, and fixed location equipment for outputting data from the basic, Option 1 and Option 2 recorders.

5.2

The status of all recorded function or calculated functions shall be indicated on each line of output. Digital events shall be shown as a " 0 " if the function is off and as a " 1 " if the function is on. Analog events shall be shown as a direct analog reading of the function. The beginning of each page of output shall contain the column headings. The format of the columns, from left to right shall be time, distance, speed, speed in excess of a zone speed limit, analog functions and digital functions.

5.3

The system shall be provided with a portable memory that shall be used to transfer the contents of the recorder memory to the output equipment.

5.4

The output equipment shall have the capability to selectively output sections of the recorded information by distance.

5.5

The output equipment shall perform calculations to obtain distance, and acceleration for the basic recorder and the Option 2 recorder.

5.6

The output equipment shall note train speeds that exceed zone speed limits and by how much. Zone speed limits for each subdivision shall be kept in permanent computer storage for access by the systems. Excess speed shall be a speed of 10% or greater than the applicable zone speed.

6.0 INTERCONNECTION WITH OTHER EQUIPMENT

6.1

The system shall provide a means to interconnect with other electronic systems on the locomotive.

6.2

Facilities shall be provided in the system for the future addition of 2 standard RS-232 interface ports.

7.0 HARDWARE REQUIREMENTS

7.1

All equipment shall be housed in enclosures if possible, equipped with internal shock mounts to protect the enclosed contents, either installed on locomotives or during transit in Railway vehicles, against the following environmental factors:

7.1.1

Vibration: 5G at 2 to 44 hertz, in any direction.

7.1.2

Shock: 20G for .015 seconds, in any direction.

7.2

Enclosures shall also protect against:

7.2.1

Electromagnetic interference (EMI) exceeding MIL-STD-461A susceptibility (conducted and radiated).

7.2.2

Contamination: Water, oil, dust, dirt, grit and any other contaminants and corrosives as may be found in the heavy Railway environment.

7.3

Enclosures shall be equipped with the following:

7.3.1

Air ventilators, as required, with replaceable dust filters that shall not be accessible from the tops or rear sides of enclosures.

7.3.2

Access covers, as required, for circuit board or other component removal and also for access to back plane wiring areas and shall be fastened to enclosures with threaded bolts and lock washers. Sheet metal screws shall not be used. Gasket material, as required, shall be used between the access cover and the enclosure.

7.3.3

A means to easily remove the enclosure from its mounting position for service replacement, and shall be provided with carrying handles.

7.3.4

Connectors for interconnection with other system components and service devices. Critical signal connectors shall be keyed to prevent damage due to incorrect plug insertion and covers shall be provided to protect connectors against contamination during transit. Connectors shall be covered or otherwise protected against easy removal by non-authorized personnel.

7.3.5

Each unit shall carry the Vendor's name and serial number.

7.4

Enclosures shall not be larger than 24 inches wide, 24 inches high and 12 inches deep.

7.5

The locomotive equipment shall have a means for entering the locomotive identity code.

7.6

All adjustable components shall be sealed to prevent any movement or change of setting.

7.7

All assemblies, components, circuit boards, sensors, switches, etc., and their mounting positions shall be clearly and permanently labelled with its functional name.

7.8

Electronic circuit boards shall be housed in an IEEE 796 card cage. Card cages shall be provided with a means to maintain circuit boards in position.

7.8.1

Electronic circuit boards shall be made of glass epoxy, no less than 3/32 of an inch thick.

7.8.2

Electronic circuit boards and components mounted on them shall be treated with a clear protective coating where necessary.

7.8.3

Electronic circuit boards shall each be designed to only fit into its position in the card cage and shall not be able to fit into positions which will prevent the system from operating.

7.8.4

Potted circuits shall not be used unless absolutely necessary and only with the approval of the Railway.

7.8.5

All electronic circuit boards except the interface circuits shall be plug-in type.

7.8.6

Electronic circuit boards shall have test points and indicator lights accessible from the front edge. Self-testing or push-to-test features shall be included where possible.

7.8.7

In order to permit possible future expansion, the card cage shall be designed to have space for approximately 25% more electronic circuit boards.

7.9

Wiring in enclosures shall be stranded, Teflon insulated and rated at 600 volts.

7.10

All electronic components, connector switches, etc., shall be according to the applicable military specification where possible and practical.

7.11

Environmentally sealed switches shall be provided.

7.12

All inputs and outputs to the system shall be provided with circuit isolation of at least 3000 volts. This does not include power supply inputs, which are covered elsewhere.

7.13

All cabling between enclosures, power supply, sensors and other equipment shall be stranded, PVC insulated, rated at 600 volts, and be 100% shielded.

7.14

After completion of the manufacture of each complete system, it shall be environmentally tested as follows:

7.14.1

The complete system shall be tested, at room temperature for 48 hours, then tested at plus 70° celsius for 48 hours, then tested at minus 40° celsius for 48 hours and then tested at room temperature for 7 days.

7.14.2

Tests shall include a continuous cycle test of the operation of the system. Air pressure shall be applied to air brake sensors.

7.14.3

The main 74 volt DC supply shall also be varied between 80 VDC and 60 VDC during the tests.

7.14.4

If a failure occurs at any time during the test, the repaired system shall be completely retested.

7.14.5

The Vendor shall forward a detailed system test report to TDC and the Chief Mechanical Officer of the Railway at time of system delivery.

7.15

The system shall perform an automatic self check test to verify that the system memory is capable of writing and reading data, all external connectors are properly inserted, and all sensors are connected. This test shall be performed each time power is applied to the system and periodically to ensure system integrity. The indicator lamp, in green color, shall be located on the equipment, and shall continuously indicate the result of this test. A solid state buzzer with an operating frequency of 1900 hertz shall be located on the equipment and switched at a 2 second rate to audibly alert service personnel of a self check test failure. If a removable memory module, when applicable, is removed, the indicator lamp shall be extinguished and the buzzer shall operate until it is replaced.

7.16

System power supply may be housed in a separate enclosure.

7.16.1

System power supply shall convert the nominal 74 volt locomotive electrical supply, using a solid state switching type, into regulated usable system voltages.

7.16.2

System power supply shall have 20,000 volt transient protection. Transients on outputs shall not exceed 120% of output voltage. All inputs and outputs shall be protected with MOV type transient suppressors. Outputs shall be protected against and withstand short circuits without any damage to any components.

7.16.3

System power supply shall have an indicator LED, for each output, to indicate the correct voltage, within 10%, is present at the output.

7.17

The system shall be provided with a 2-pole circuit breaker for circuit protection and shall be mounted inside the equipment enclosure. Fuses shall not be used.